Exploring the Many Perspectives of Distributed Air Traffic Management: The Multi Aircraft Control System MACS

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Acknowledgements

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  - Stephan Romahn
- Collaborators at NASA Ames:
  - Ev Palmer, Nancy Smith, Todd Callantine
- Additional MACS developers
  - Michael Downs, Khan Trinh, Rick Jacoby

Contents

Background

- Air traffic management research of future concepts needs to address all players including flight crews, air traffic controllers/ managers and airline dispatchers adequately

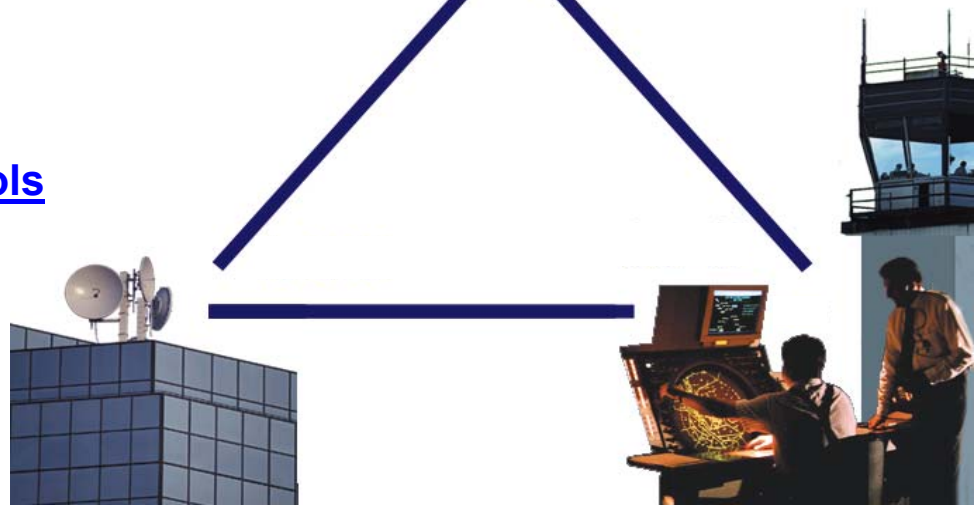
- Among the ways of addressing the problem are
  - Include many participants (pilots, controllers, dispatchers) in a given air traffic simulation to work all sides of the problem adequately.
  - Include automated agents for side aspects and human participants only for the focus area of the research.

Distributed Concept (DAG)

Automation:
- CDTI
- Conflict probe
- FMS
- Data link

Flight Crew Role:
- Assure separation en route
- Plan conflict free flight paths
- Follow FMS flight paths precisely
- Self-merging and spacing

Flight Deck



Automation tools
- Planning
- Scheduling
- Data link

Automation
- Traffic Management
- Conflict probe
- Descent Advisor
- Data link

Airline Operational Control

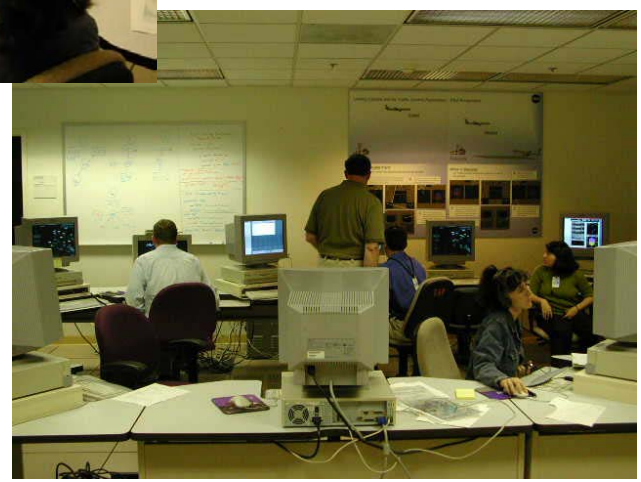
Air Traffic Control

AOC Role:
- Determine preferences
- Coordinate

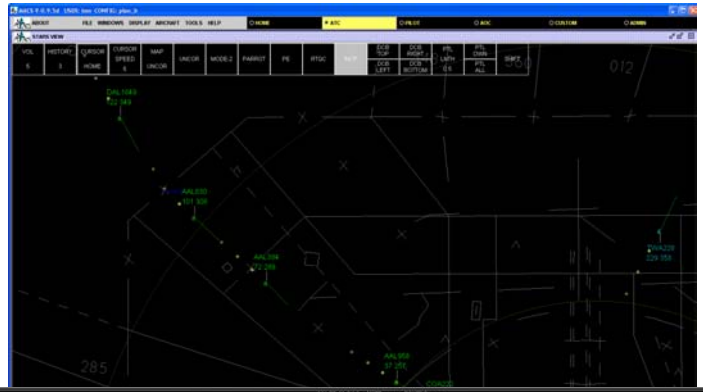
Planner Role:
- Generate Schedule
- Assist flight crews and ATC

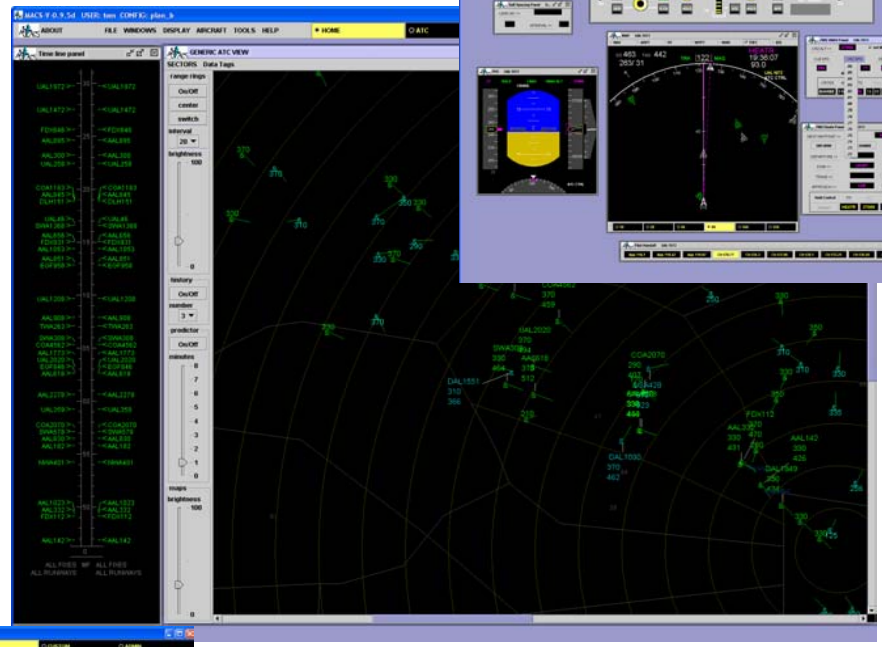
Controller Role:
- Assure separation in Terminal area
- Adjust flight paths

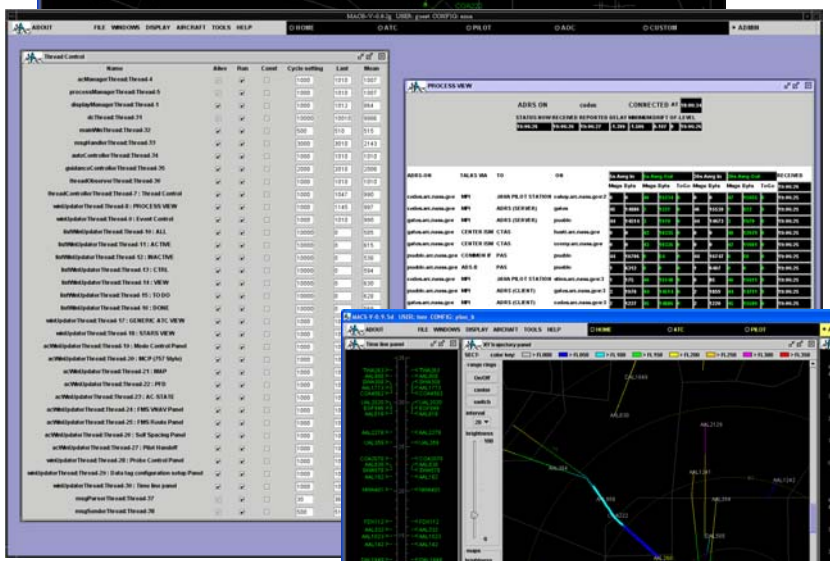
One Common Situation - Many Perspectives

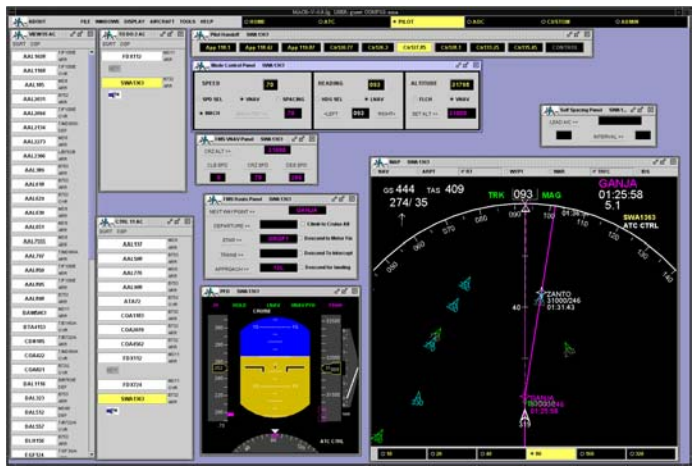


All Perspectives As MACS Views









MACS Views

- All views can be configured individually by the operator
- Windows can be mixed and matched

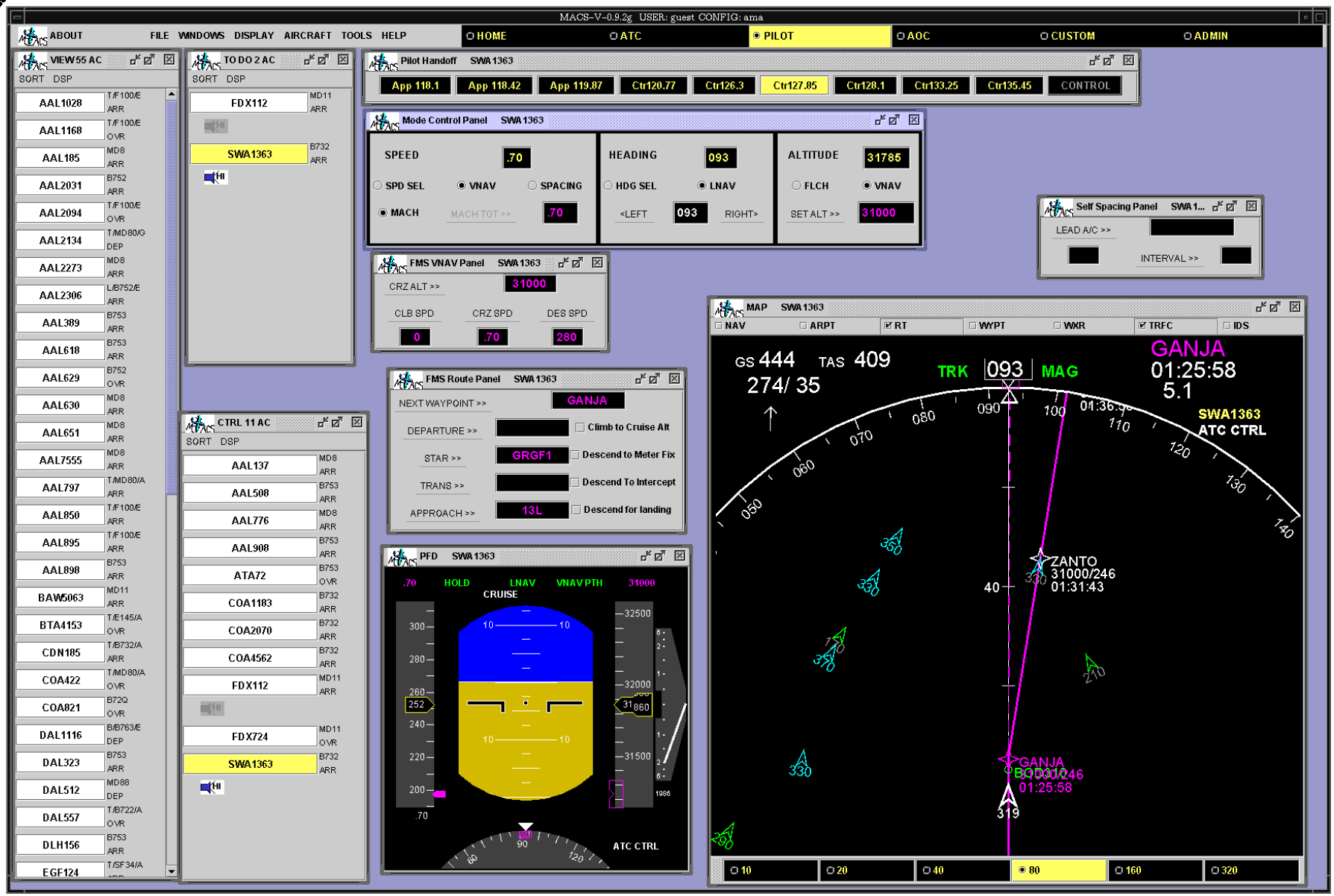
MACS Design and Architecture

- Only JAVA code is used
- Tested and used on Windows, UNIX and LINUX platforms with free compilers and virtual machines
- Very robust multi threaded process:
  - each window is updated by it's own thread
  - Most threads can be stopped and restarted and are automatically restarted if a problem is detected
  - All thread update rates can be configured in real-time by the operator and tailored to the particular station use
- Design goals:
  - Simple and intuitive operator interactions
  - Configurable for different levels of automation

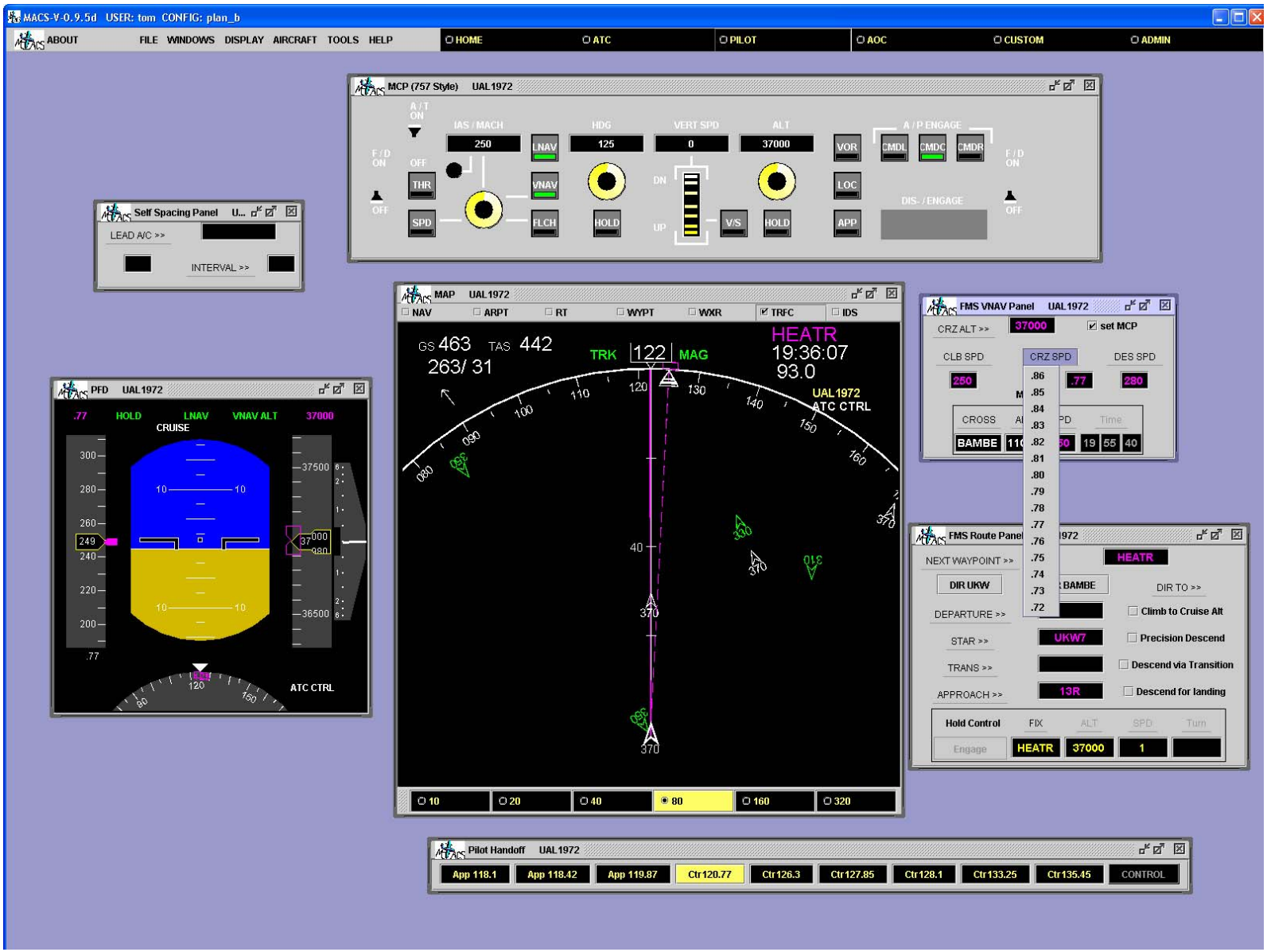
MACS capabilities

- Full performance multi aircraft pilot stations:
  - Experienced operators typically handle 8-20 aircraft per station opposite FPL controllers
- Enroute and TRACON “FMS-like” guidance flies aircraft accurately close to the ground
- Event controller “Auto-Mode” enables automatic flight for all aircraft in a simulation
- On-line analysis of aircraft trajectories and crossing restrictions
- Several ATC views (DSR, STARS, Generic) are available and currently completed

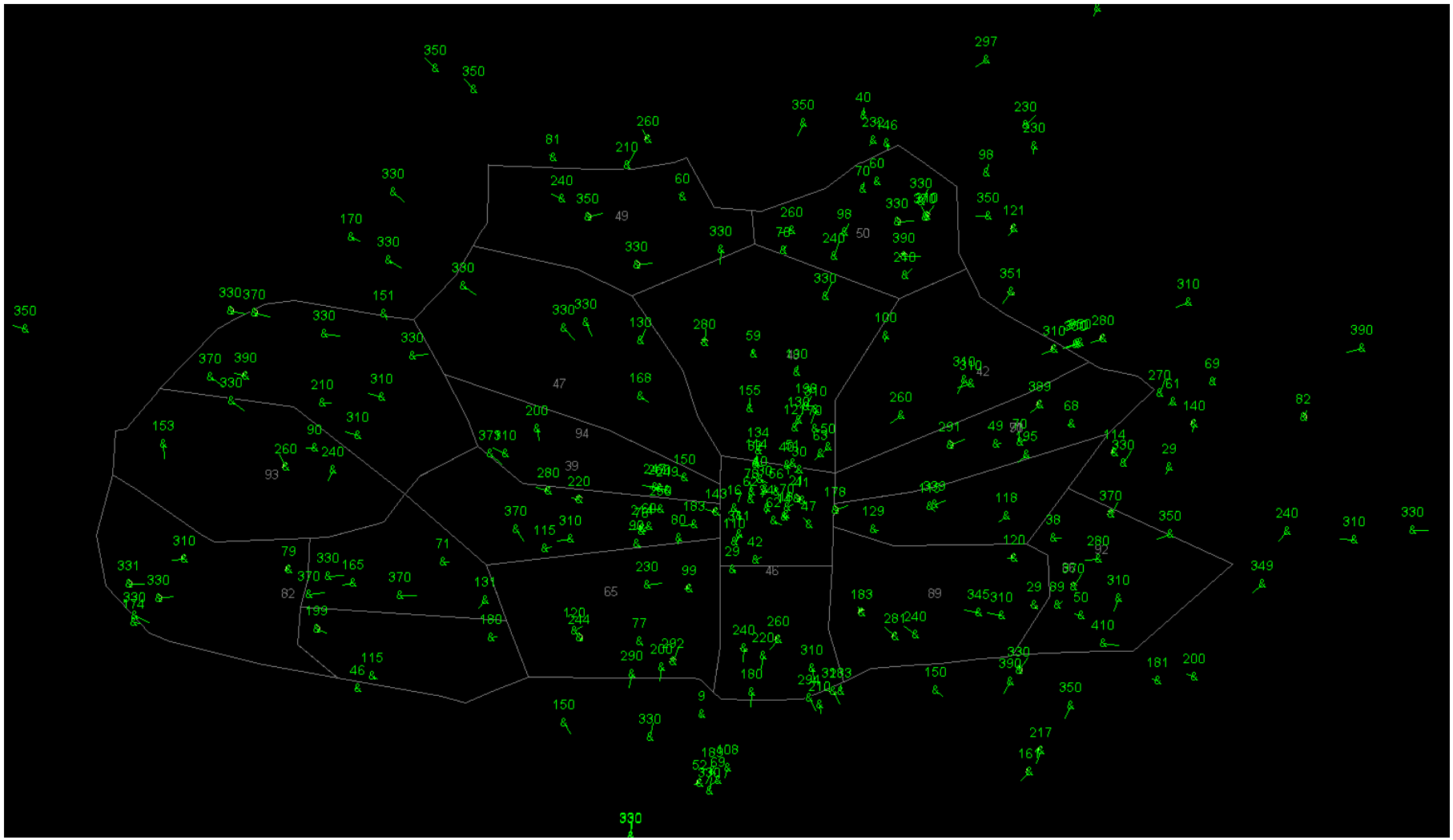
Pilot View


MACS-V-0.9.2g USER: guest CONFIG: ama
ABOUT FILE WINDOWS DISPLAY AIRCRAFT TOOLS HELP
HOME ATC PILOT AOC CUSTOM ADMIN
VIEW 55 AC
TO DO 2 AC
Pilot Handoff SWA1363
App 118.1 App 118.42 App 119.87 Ctr120.77 Ctr126.3 Ctr127.85 Ctr128.1 Ctr133.25 Ctr135.45 CONTROL
Mode Control Panel SWA1363
SPEED .70 HEADING 093 ALTITUDE 31785
SPD SEL VNAV SPACING HDG SEL LNAV FLCH VNAV
MACH MACH TGT >> .70 <LEFT 093 RIGHT> SET ALT >> 31000
Self Spacing Panel SWA1...
LEAD A/C >> INTERVAL >>
FMS VNAV Panel SWA1363
CRZ ALT >> 31000
CLB SPD CRZ SPD DES SPD
0 .70 280
FMS Route Panel SWA1363
NEXT WAYPOINT >> GANJA
DEPARTURE >> Climb to Cruise Alt
STAR >> GRGF1 Descend to Meter Fix
TRANS >> Descend To Intercept
APPROACH >> 13L Descend for landing
CTRL 11 AC
MAP SWA1363
NAV ARPT RT WYPT WXR TRFC IDS
GS 444 TAS 409
274/ 35
TRK 093 MAG
GANJA
01:25:58
5.1
SWA1363
ATC CTRL
ZANTO
31000/246
01:31:43
PFD SWA1363
.70 HOLD LNAV VNAV PTH 31000
CRUISE
ATC CTRL
10 20 40 80 160 320

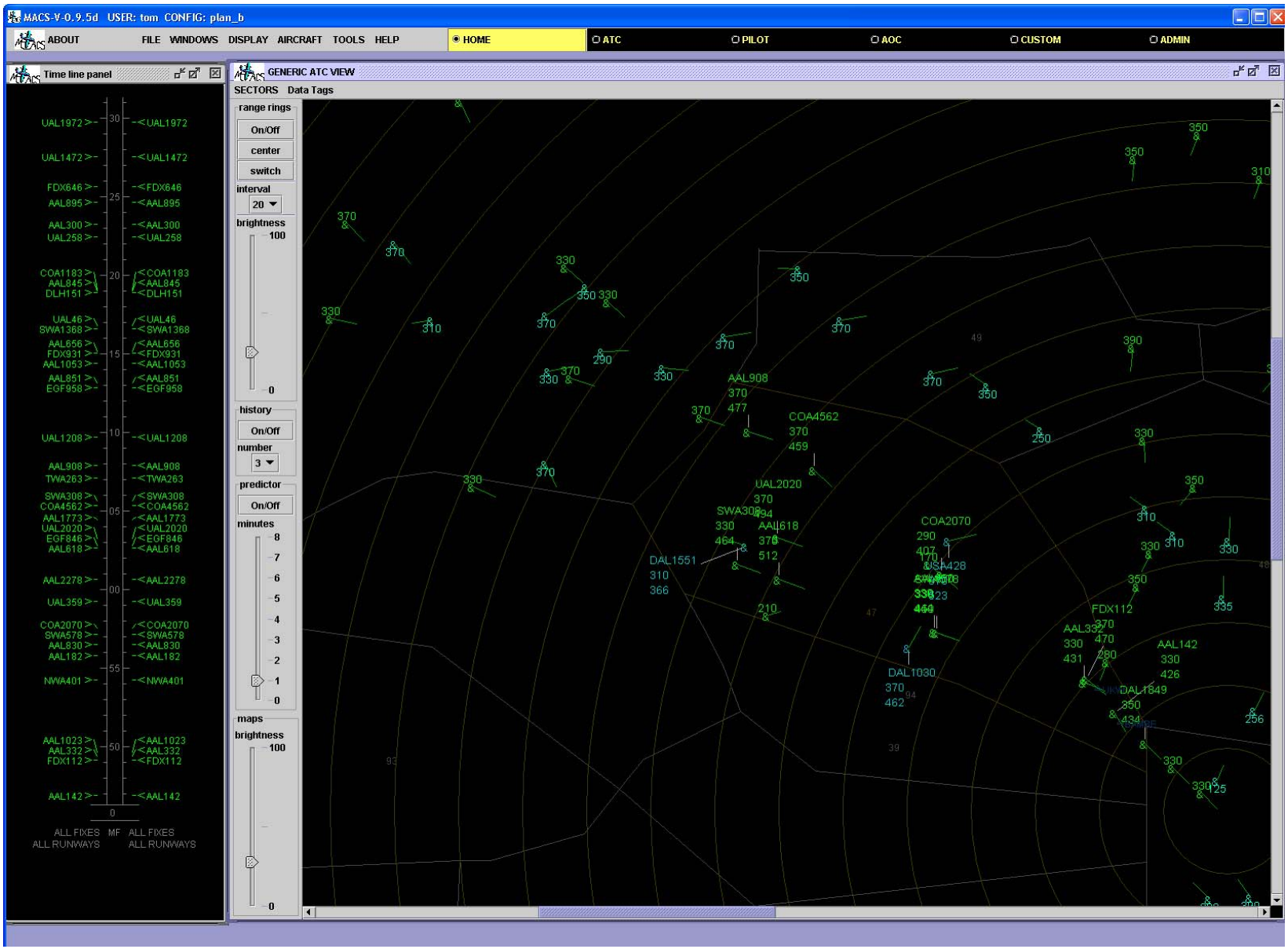
MACS Single Pilot Station



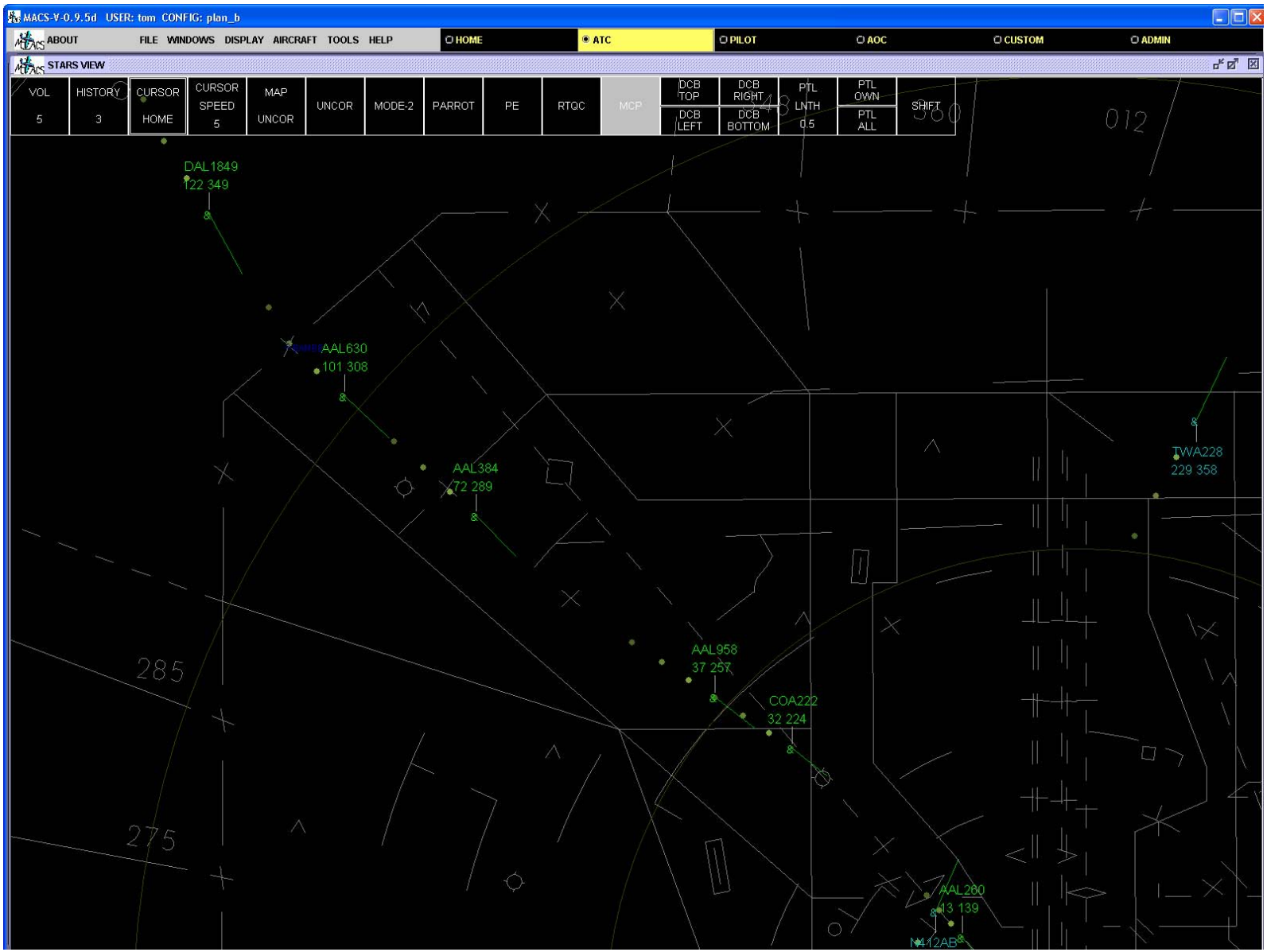
ATC view



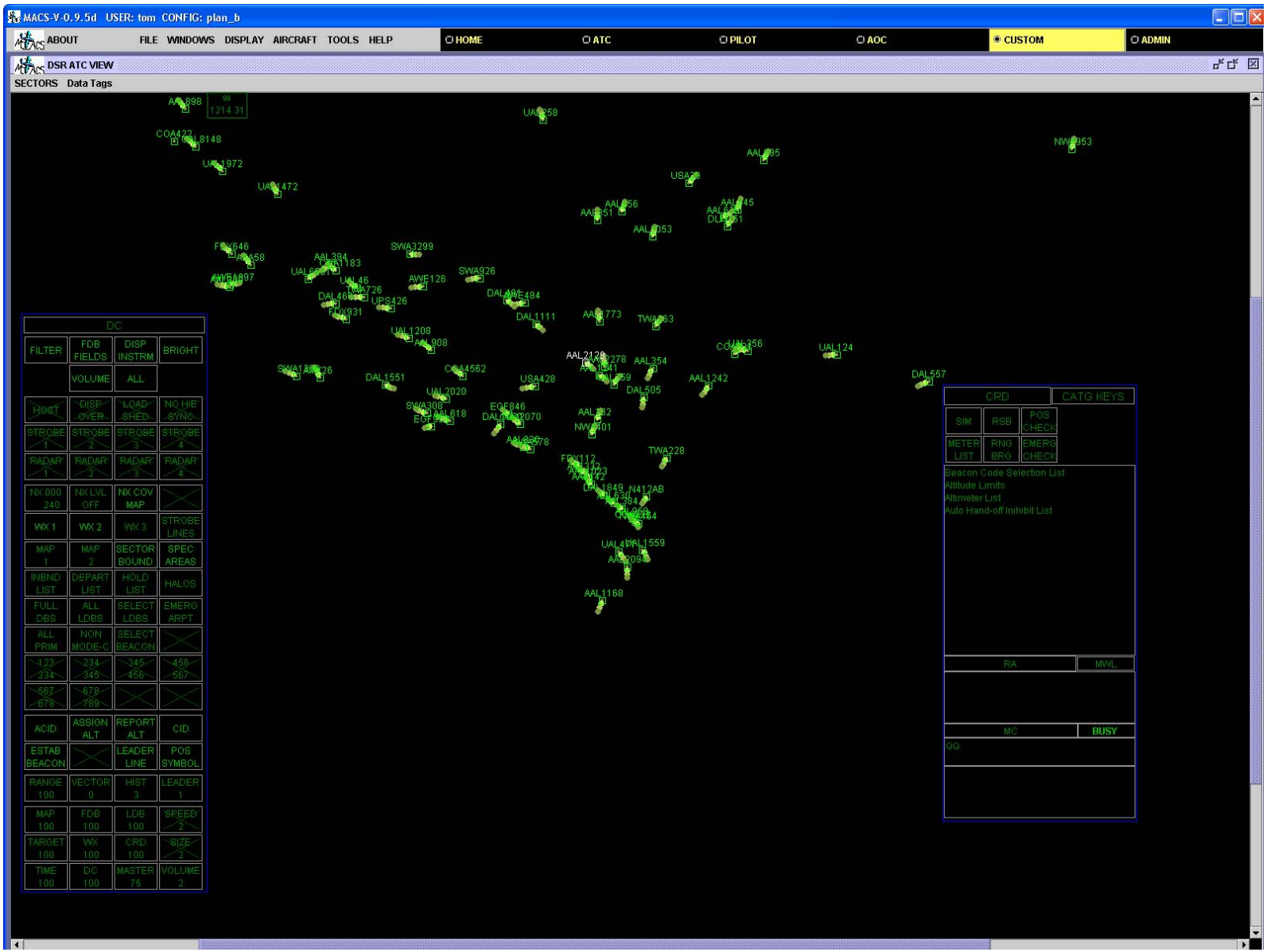
Generic ATC view



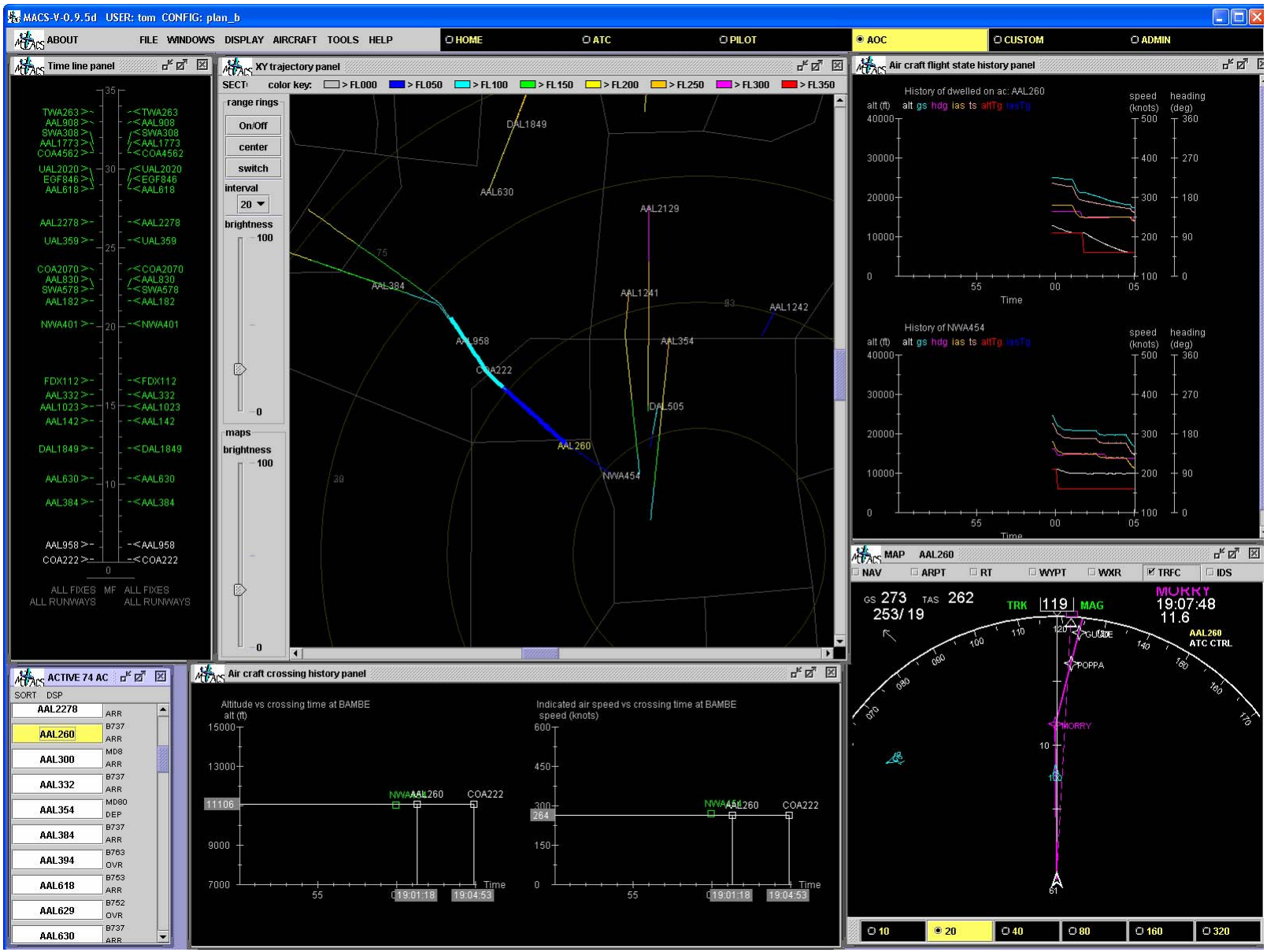
STARS View


MACS-V-0.9.5d USER: tom CONFIG: plan_b
ABOUT FILE WINDOWS DISPLAY AIRCRAFT TOOLS HELP
HOME ATC PILOT AOC CUSTOM ADMIN
STARS VIEW
VOL 5
HISTORY 3
CURSOR HOME
CURSOR SPEED 5
MAP UNCOR
UNCOR
MODE-2
PARROT
PE
RTQC
MCP
DCB TOP
DCB RIGHT
DCB LEFT
DCB BOTTOM
PTL LNTH 0.5
PTL OWN
PTL ALL
SHIFT
DAL1849
122 349
AAL630
101 308
AAL384
172 289
TWA228
229 358
AAL958
37 257
COA222
32 224
AAL260
43 139
285
275
012

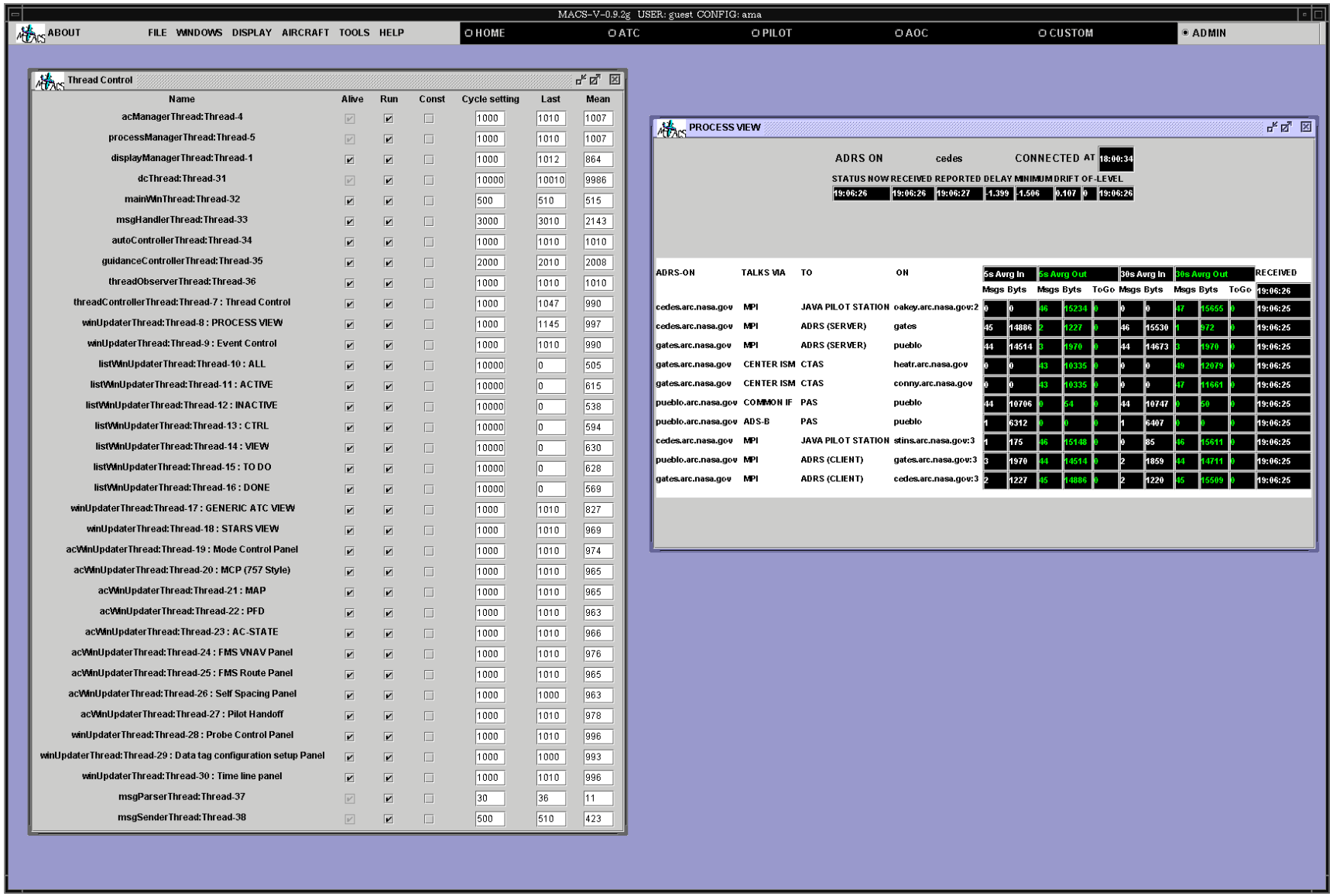
DSR ATC View


MACS-V-0.9.5d USER: tom CONFIG: plan_b
ABOUT
FILE
WINDOWS
DISPLAY
AIRCRAFT
TOOLS
HELP
HOME
ATC
PILOT
AOC
CUSTOM
ADMIN
DSR ATC VIEW
SECTORS
Data Tags
DC
FILTER
FDB FIELDS
DISP INSTRM
BRIGHT
VOLUME
ALL
HOST
DISP OVER
LOAD SHED
NO H/E SYNC
STROBE 1
STROBE 2
STROBE 3
STROBE 4
RADAR 1
RADAR 2
RADAR 3
RADAR 4
NX 000 240
NX LVL OFF
NX COV MAP
WX 1
WX 2
WX 3
STROBE LINES
MAP 1
MAP 2
SECTOR BOUND
SPEC AREAS
INBND LIST
DEPART LIST
HOLD LIST
HALOS
FULL DBS
ALL LDBS
SELECT LDBS
EMERG ARPT
ALL PRIM
NON MODE-C
SELECT BEACON
123 234
234 345
345 456
456 567
567 678
678 789
ACID
ASSIGN ALT
REPORT ALT
CID
ESTAB BEACON
LEADER LINE
POS SYMBOL
RANGE 100
VECTOR 0
HIST 3
LEADER 1
MAP 100
FDB 100
LDB 100
SPEED 2
TARGET 100
WX 100
CRD 100
SIZE 2
TIME 100
DC 100
MASTER 75
VOLUME 2
CRD
CATG KEYS
SIM
RSB
POS CHECK
METER LIST
RNG BRG
EMERG CHECK
Beacon Code Selection List
Altitude Limits
Altimeter List
Auto Hand-off Inhibit List
RA
MVL
MC
BUSY
QQ

Analysis View

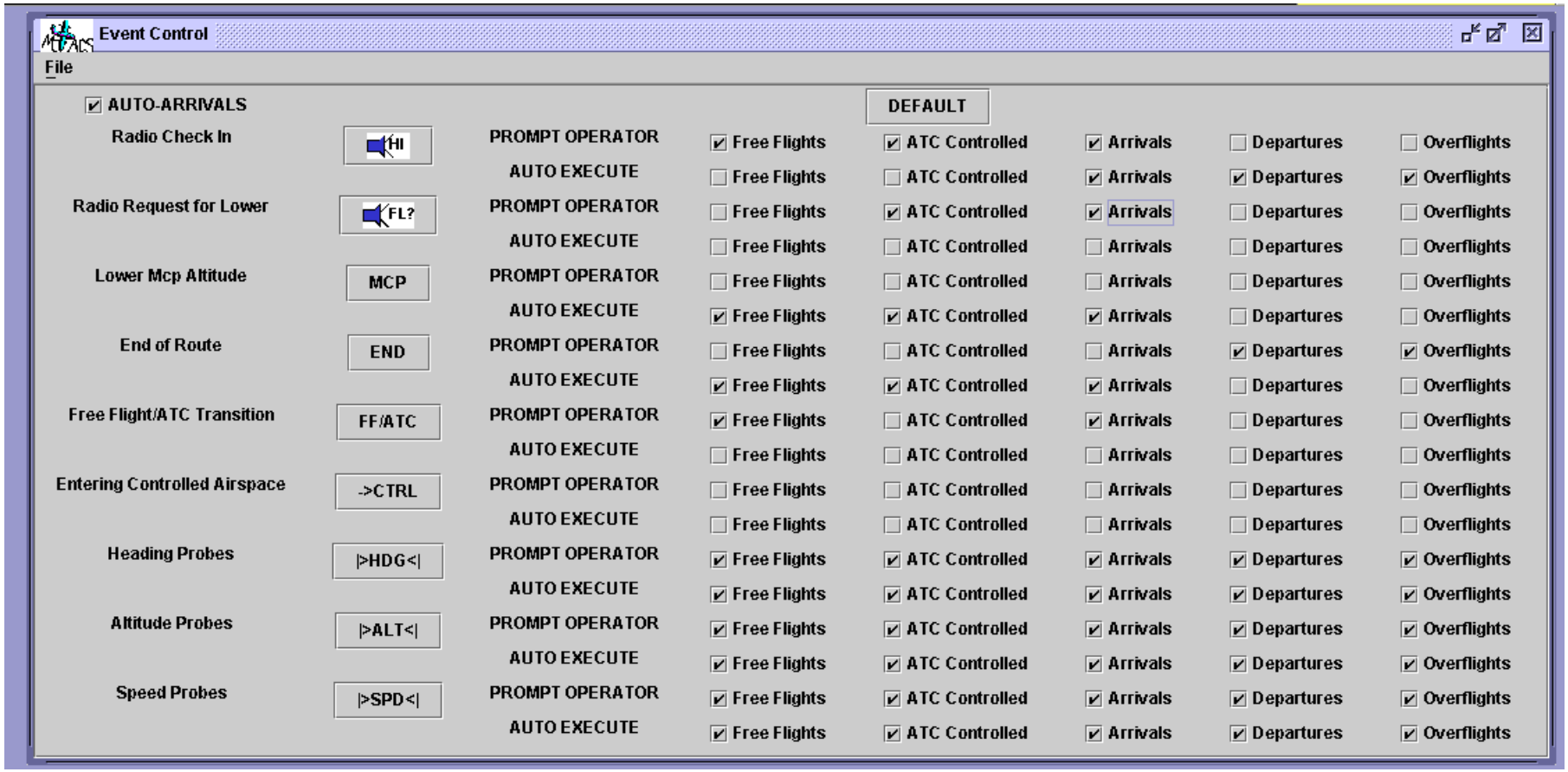


Experimenter View

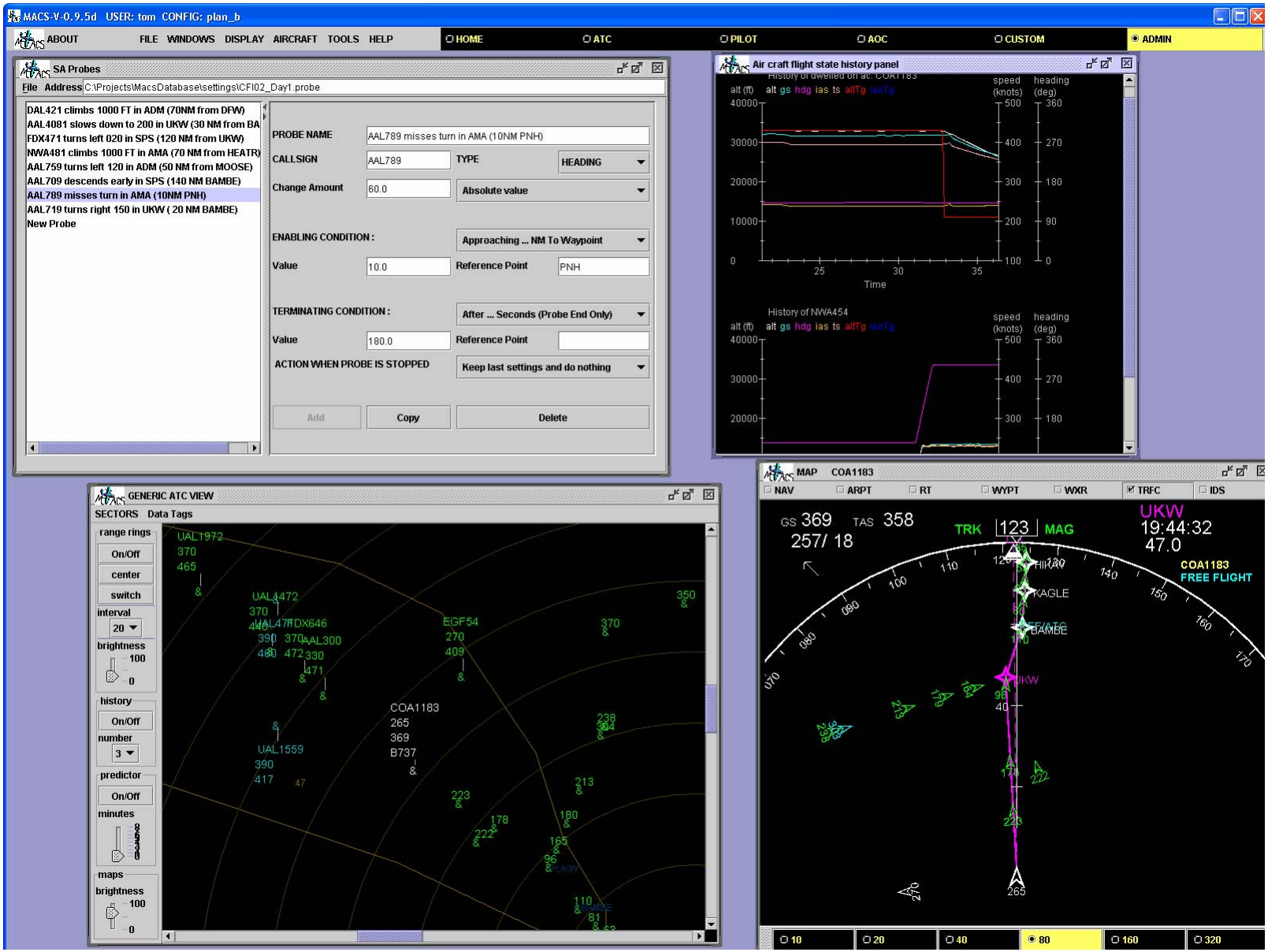


Operator Support and Automated Agents

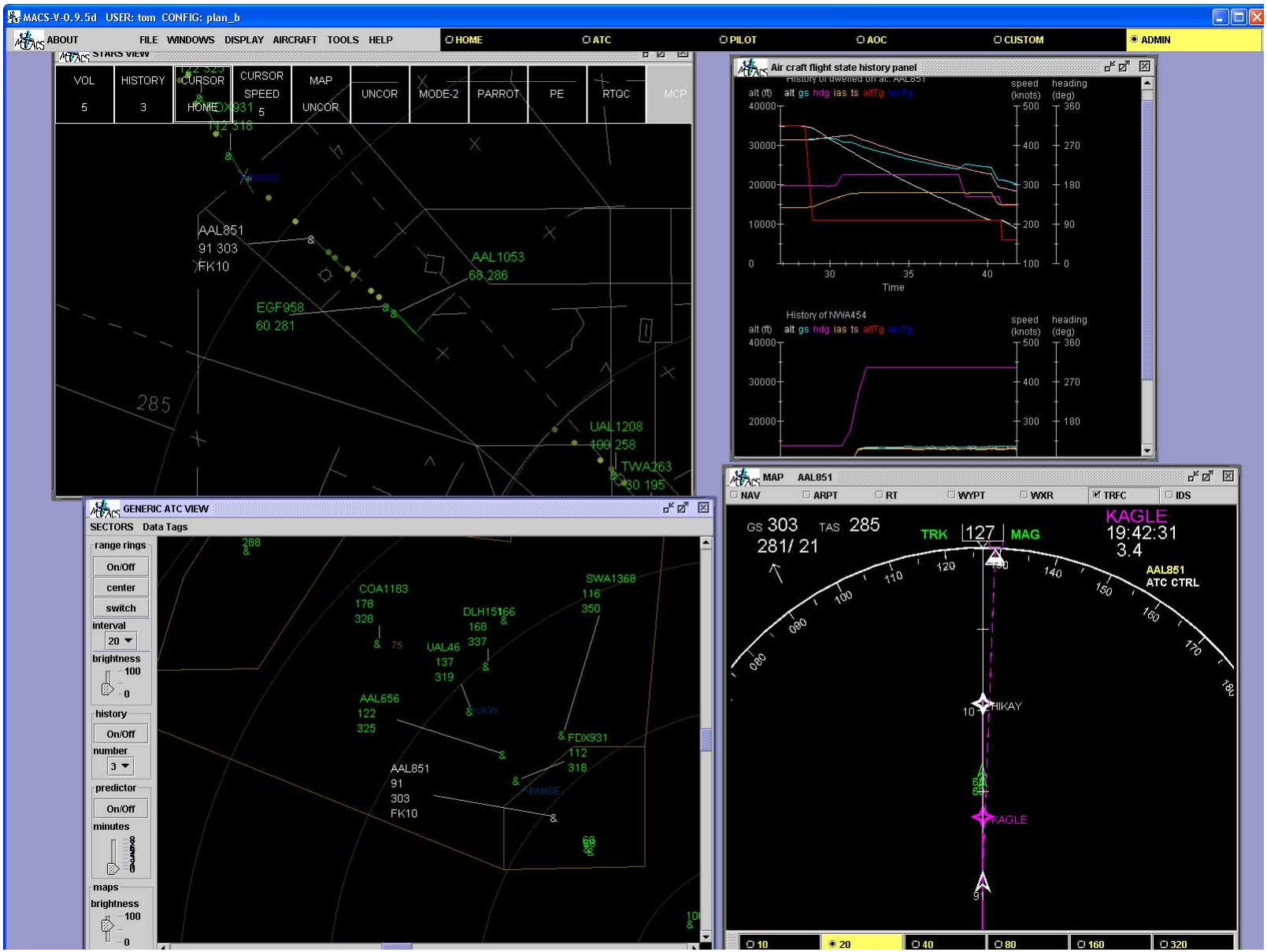
- MACS can be configured for automatically performing tasks or prompting operators



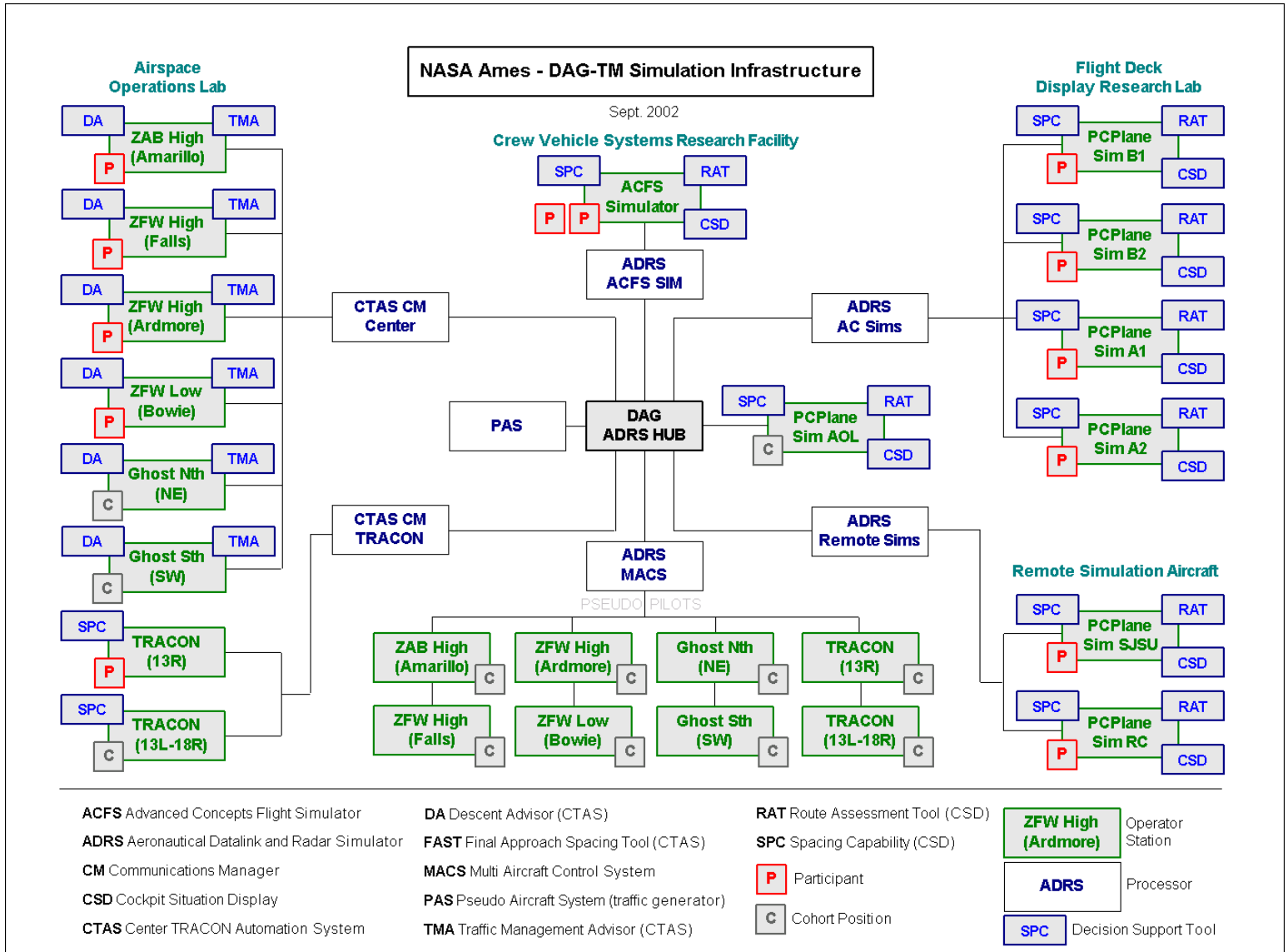
Windows can be combined as desired



MACS Windows



Current DAG Simulation Architecture



ADRS*- The Distributed Simulation Hub

- **Aeronautical Datalink and RADAR Simulator*

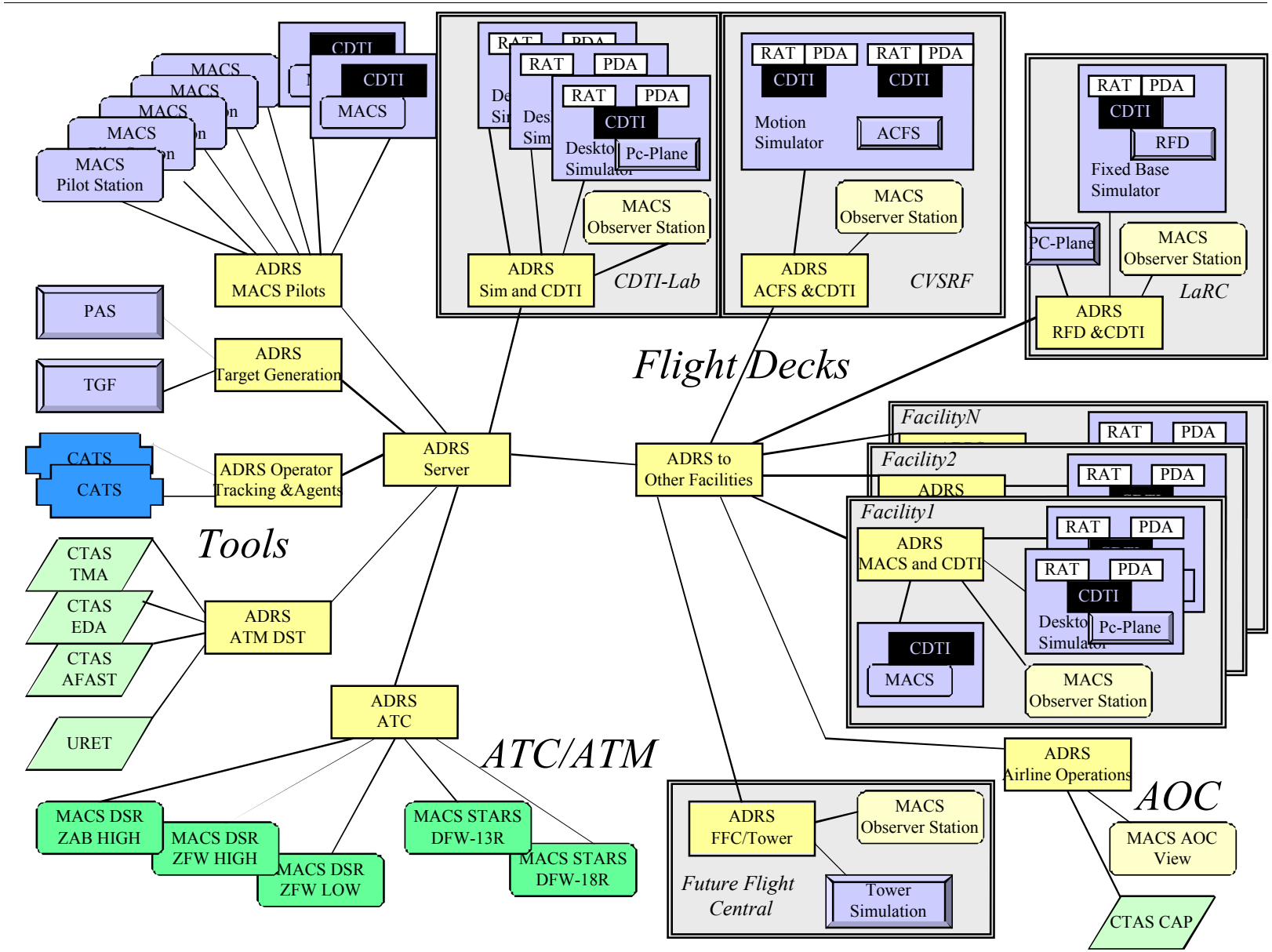
- Distribution of communication load:
  - Unlimited number of servers and clients can be connected by adding identical ADRS processes to the simulation network that share their information
- Host emulation
- Radar simulation
- Datalink simulation
- Aircraft state and trajectory data harmonization and maintenance
- Process control and monitoring

MACS usage in current DAG Simulations (Ongoing)

- CTAS/FMS 2002 data collection. Evaluation of trajectory based vs. sector based concepts of managing arrival traffic with FPL controllers and air traffic managers.
  - AOL, MACS, PAS, CTAS

- Frequent workshops, demonstrations and evaluations of distributed concepts that investigate free-flight concepts with airborne and ground-based conflict resolution techniques, new separation responsibilities and airspace restructuring with controllers, pilots, dispatchers and researchers.
  - AOL, ACFS, PC-Plane, MACS, CDTI, PAS, CTAS

Upgrading and Expanding



Concluding remarks

- Realistic human-in-the-loop simulations of future distributed air traffic management will require participation of numerous pilots, controllers, airline dispatchers, researchers and the operational community alike
- The multi-fidelity simulation environment at NASA Ames has been successfully used for many demonstrations and evaluations
- The simulation will be upgraded and expanded to include more research facilities on and off-site as active participants, observers, or data analysts.
- Currently MACS is used for pilot stations and for automatically guiding aircraft. It will aslo replace the controller workstations.

Information on the World Wide Web

http://human-factors.arc.nasa.gov/ihi/research_groups/air-ground-integration

http://human-factors.arc.nasa.gov/ihh/cdti/DAG_TM_WEB/dag2001.html

http://www.arc.nasa.gov/aatt